149. Investigation of Precipitation Characteristics during NASA GV Field Projects

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Introduction

Previous work has shown large variability in cloud microphysics, and hence surface rainfall, depending on meteorological regime. For example, Bringi et al. (2009) showed a difference in convective and stratiform mean drop sizes (D_0), as well as differences between the monsoon and break periods in Darwin. Cloud microphysics can also vary spatially, temporally, and topographically. *Using the extensive datasets collected by recent NASA Ground Validation (GV) field experiments, we examine the environmental controls on DSD parameters such as D_0 and normalized number concentration (N_w) in the hopes of possibly providing information to constrain space- and ground-based radar rainfall retrievals*. Our hypothesis is that stronger, more organized convection (through larger CAPE and moderate shear) produces larger maximum updrafts, larger precipitation ice (graupel and hail) aloft consuming available supercooled water and resulting in larger but fewer drops at the surface. The stratiform regions are enhanced through increased convergence and strong mesoscale ascent resulting in larger aggregates, stronger bright bands and larger drops at the surface. Herein we examine data from the 2011 Mid-latitude Continental Convective Cloud Experiment (MC3E) and 2013 Iowa Flood Studies (IFloodS).

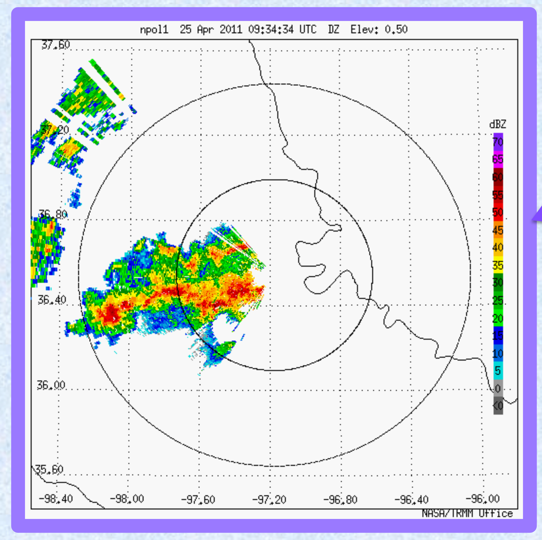
Methodology

- Examine data from the polarimetric S-band NPOL radar and network of surface 2D video disdrometers (2DVD)
- 2DVD and NPOL data were matched for precipitating times over each entire field project, resulting in 9 cases for MC3E and 16 cases for IFloodS. This was done to examine if both radar and disdrometer give consistent correlation trends, since the radar samples a much larger area than disdrometer
- Data were divided into convective and stratiform using a 38 dBZ threshold
- RUC (MC3E) and RAP (IFloodS) reanalysis points were collected for the point nearest the disdrometers and hourly surface parameters were extracted: CAPE, warm cloud depth (WCD), cloud base height (CBH), temperature (T), dew point (Td)
- Hourly means of disdrometer and radar data were correlated to environmental parameters using Spearman correlations
- Apply radar self-consistency (relationship between differential reflectivity (Z_{dr}) and the ratio of specific differential phase (K_{dp}) to linear reflectivity (Z_h)

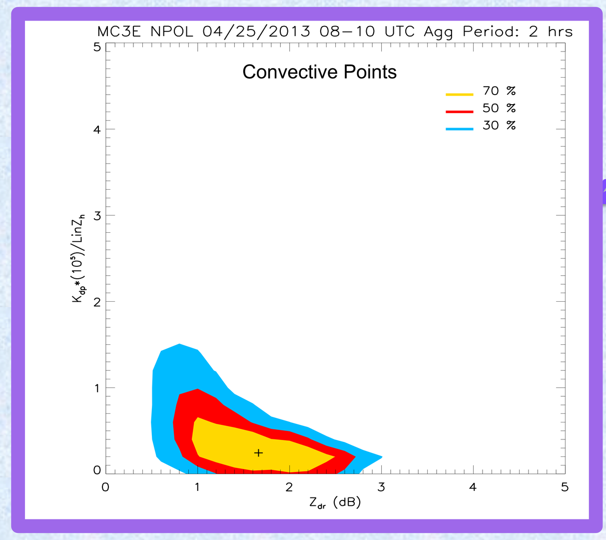
Example Cases

MC3E

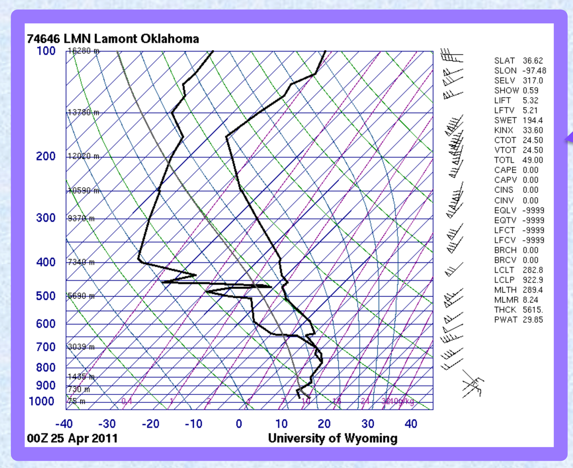
25 April



Elevated Nocturnal Convection

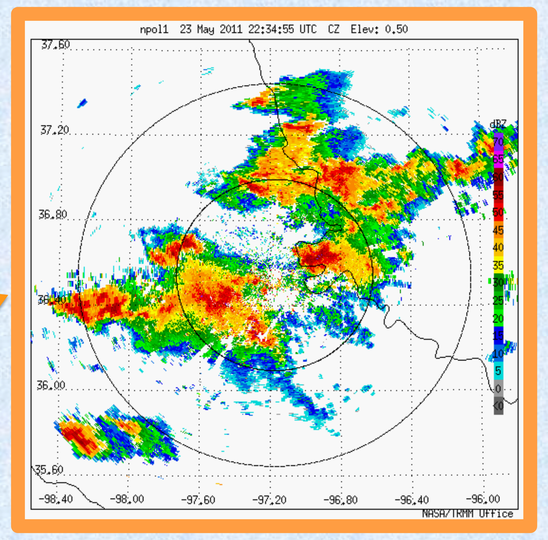


- Most frequent Z_{dr} / K_{dp}/Z_h pair at (1.7 dB, 0.3)
- 'Tail' to higher K_{dp}/Z_h

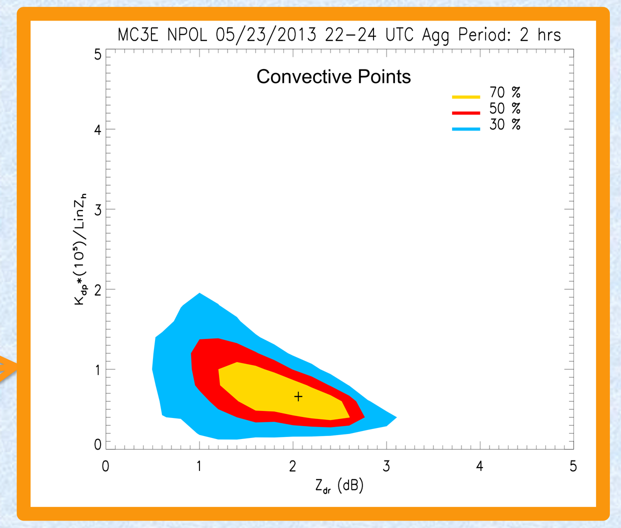


- 100 J CAPE
- 95% RH
- 75 m CBH
- 3300 WCD
- 13.8 ° C

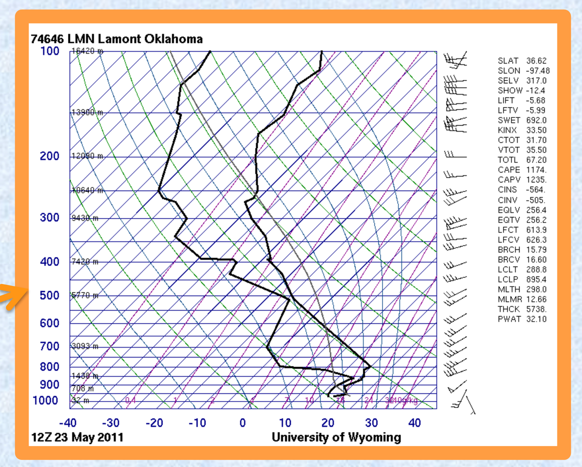
23 May



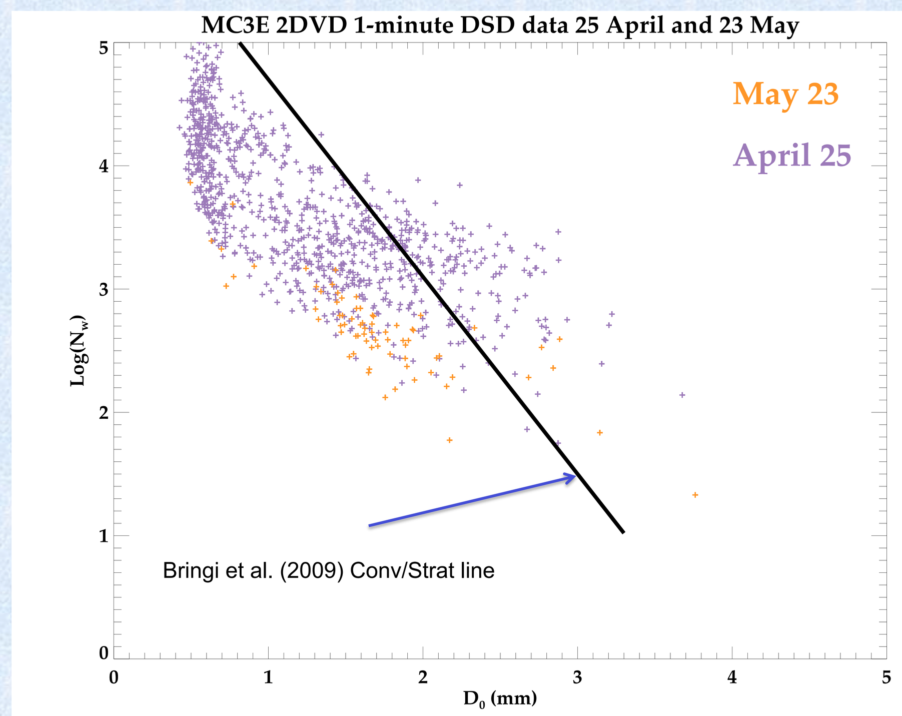
Dry line Initiated Afternoon Convection



- Higher mean Z_{dr} (2.1) and higher K_{dp}/Z_h (0.7)

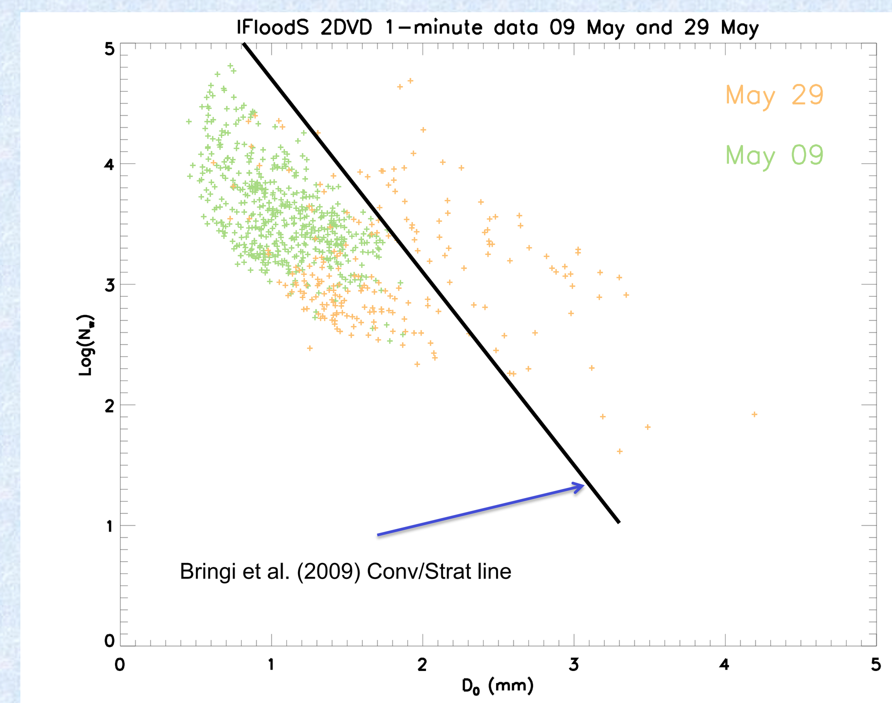


- 2900 J CAPE
- 77% RH
- 600 m CBH
- 3400 WCD
- 25.8 ° C



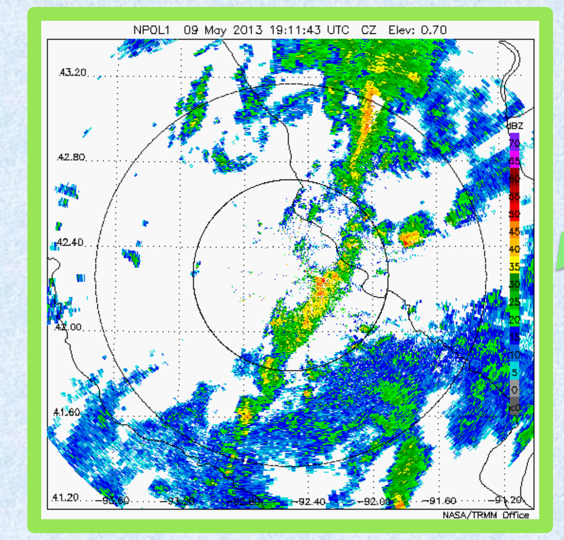
- For a given D_0, $\log(N_w)$ is generally higher for the April 25 case
- Lots of small drops during April 25 (cluster around D_0=0.5-0.6 mm, $\log(N_W) > 3.5$)
- Couple of large D_0, low N_w for May 23
- 25 April is cooler with lower cloud base and almost no CAPE compared with 23 May

IFloodS

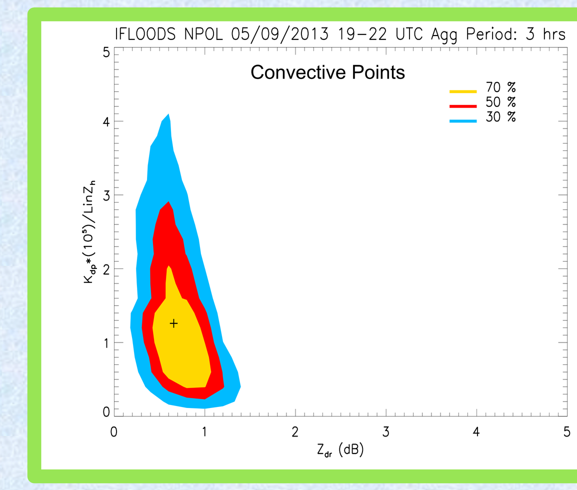


- Smaller D_0, larger $\log(N_w)$ for 09 May case compared to 29 May
- No points cross the Bringi et al. (2009) Convective / Statiform line on 09 May
- May 09 is cooler with lower cloud base height and small amount of CAPE compared with 29 May

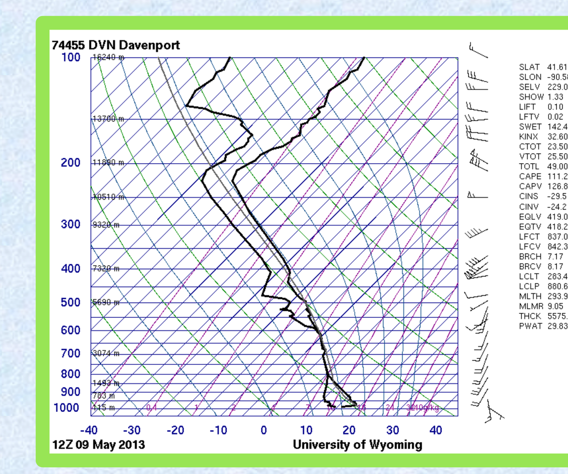
09 May



Weak Convective Line

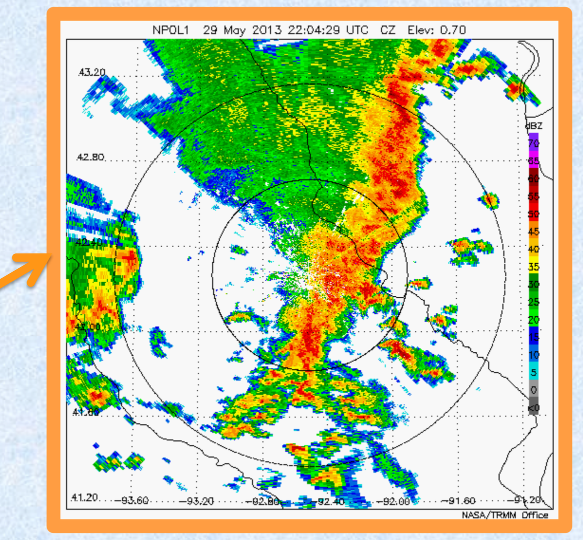


- Small median Z_{dr} (0.6) and wide range of K_{dp} / Z_h
- Z_{dr} generally below 1.5 dB

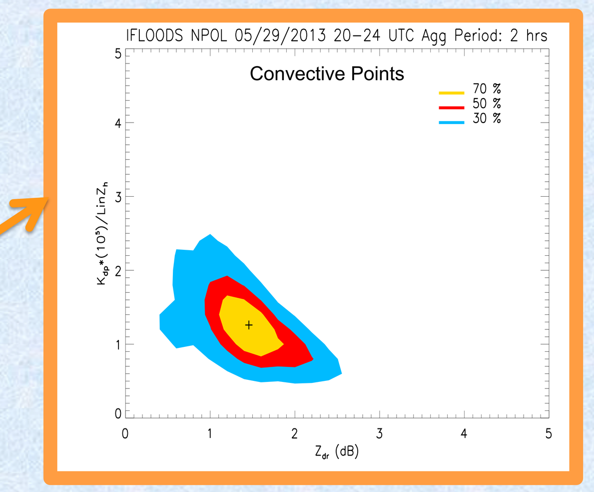


- 300 J CAPE
- 2700 m WCD
- 13.8 ºC
- 95% RH
- 130 m CBH

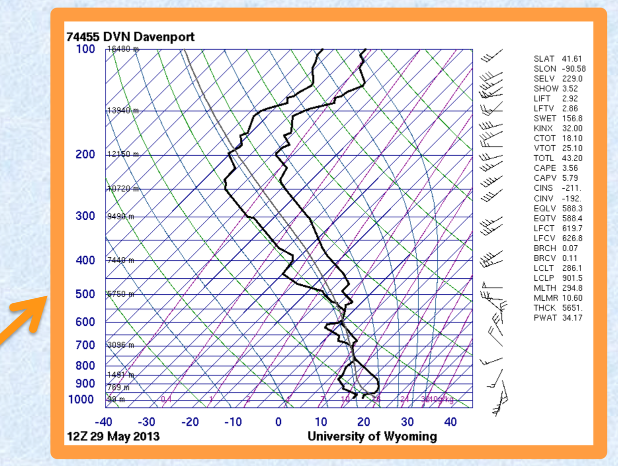
29 May



Strong MCS



- Larger median Z_{dr} and maximum Z_{dr} approaching 2.6 dB
- Smaller K_{dp}/Z_h spread than May 9 case
- Generally higher median K_{dp}/Z_h, but lower median Z_{dr}, than MC3E cases



- 1400 J CAPE
- 3200 m WCD
- 22 ºC
- 75% RH
- 510 m CBH

Correlations

MC3E Convective Hourly Correlations

Disdrometer data / Radar data	CAPE	WCD	CBH	TEMP	TD
D_0	0.24	0.39	0.38	0.24	0.36
$Log_{10}(N_w)$	-0.66	-0.07	-0.78	-0.64	-0.69
LWC	-0.67	0.65	-0.77	-0.60	-0.52
RR	-0.45	0.81	-0.49	-0.1	-0.29
DBZ	-0.61	0.62	-0.55	-0.60	-0.53
Zdr	-0.15	0.53	-0.07	-0.18	-0.02
Kdp	-0.94	0.83	-0.57	-0.95	-0.88

- Moderate to strong positive correlations between D_0, LWC, RR, dBZ, Z_{dr}, K_{dp} and warm cloud depth
- Negative correlations with CAPE, CBH, Temp and T_d and $\log(N_w)$, LWC, RR, DBZ, Z_{dr} and K_{dp}

- Convection
  - Deep warm cloud depth allows for efficient melting of large precipitation ice
- Stratiform
  - Higher cloud base heights result in larger but fewer drops at the surface -> evaporation?

MC3E Stratiform Hourly Correlations

Disdrometer data / Radar data	CAPE	WCD	CBH	TEMP	TD
D_0	0.15	-0.08	0.37	0.27	0.19
$Log_{10}(N_w)$	-0.24	0.24	-0.40	-0.20	-0.09
LWC	0.00	0.18	-0.03	0.15	0.13
RR	-0.02	0.11	0.04	0.13	0.10
DBZ	0.08	-0.05	0.18	0.08	0.12
Zdr	0.08	-0.08	0.21	0.12	0.07
Kdp	-0.31	0.12	0.13	-0.10	-0.20

- Moderate positive (negative) correlation between D_0 (N_w) and cloud base height. Not as evident in polarimetric data
- This indicates larger but fewer drops with increasing cloud base height

IFloodS Convective Hourly Correlations

Disdrometer data / Radar data	CAPE	WCD	CBH	TEMP	TD
D_0	0.40	0.44	0.13	0.32	0.31
$Log_{10}(N_w)$	-0.05	-0.29	0.07	-0.06	-0.05
LWC	0.44	0.36	0.17	0.33	0.34
RR	0.47	0.36	0.21	0.37	0.36
DBZ	0.44	0.00	0.25	0.44	0.37
Zdr	0.36	0.25	0.38	0.37	0.27
Kdp	0.55	0.37	0.19	0.51	0.51

- In contrast to MC3E, general moderate positive correlations between most DSD and radar variables and CAPE, WCD, Temp and T_d
- N_w is weakly negatively correlated, strongest correlation with WCD

- Convection
  - More CAPE, T and higher T_d, result in stronger updrafts and thus larger precipitation ice which consume available supercooled water resulting in larger drops (larger D_0, Z_{dr}) that melt through a deep warm cloud
- Stratiform
  - Deep warm cloud depth allows for efficient melting of large aggregates

IFloodS Stratiform Hourly Correlations

Disdrometer data / Radar data	CAPE	WCD	CBH	TEMP	TD
D_0	-0.09	0.52	-0.04	0.00	-0.03
$Log_{10}(N_w)$	-0.01	-0.35	0.04	-0.07	-0.04
LWC	-0.02	0.30	0.01	-0.04	-0.03
RR	-0.01	0.36	0.01	-0.01	-0.01
DBZ	-0.24	0.24	-0.13	-0.23	-0.21
Zdr	0.15	0.31	0.17	0.27	0.22
Kdp	0.21	-0.07	0.09	0.26	0.26

- Largest correlations with warm cloud depth and drop size (D_0, Z_{dr}) as well as LWC and RR
- $Log(N_w)$ inversely correlated with WCD

Conclusions

By examining different convective cases occurring in different locations (Oklahoma and Iowa) under different environmental conditions, we can see some variability in DSD and radar self-consistency space. That is, cases with more CAPE, deeper WCD, higher CBH and warmer surface temperatures tend to result in surface DSDs with larger D_0 but lower N_w. Warm cloud depth was consistently moderately correlated with DSD and radar parameters in both regions. In radar space, these cases are associated with larger convective Z_{dr} values and lower K_{dp} / Z_h ratios. We speculate this is due to larger precipitation ice grown aloft and larger aggregates, which then melt efficiently in deep warm cloud depths. Interestingly, median and maximum Z_{dr}'s are larger over the MC3E region compared to IFloodS, but K_{dp}/Z_h ratios are lower. Future work will include expanding the analysis to IPHEx and OLYMPEx regions, as well as expanding the radar and disdrometer analysis beyond matched times.

Acknowledgements

This work is supported by NASA grants NNX13AG32G, NNX14AH06G and DOE DE-SC0007016. Thank you to Merhala Thurai, Ali Tokay, Elizabeth Thompson, Brody Fuchs for assistance with data processing and acquisition.